AN EVALUATION OF WETLAND MITIGATION SITE COMPLIANCE AT THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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Abstract: In 2004, Washington State Department of Transportation (WSDOT, or the Department) biologists evaluated the effectiveness of the Department's wetland mitigation sites. These sites were developed to compensate for unavoidable impacts to wetlands that occurred as highway improvement projects were completed. This evaluation includes 30 WSDOT mitigation sites with designated monitoring periods that ended between 2000 and 2003. To assess the effectiveness of these mitigation efforts, Department biologists evaluated success in meeting wetland acreage requirements, achieving site success standards, and replacing wetland functions using wetland ratings as a surrogate for function evaluation. Records from this study indicate 100.86 acres of wetland creation, restoration, enhancement, and preservation were required as mitigation for 47.06 acres of project impacts. Wetland delineations completed at the end of the initial monitoring periods show the Department successfully provided 92.33 acres (91.5 percent) of required compensatory mitigation area. In addition, 96 success standards (55.5 percent) were achieved, while 77 standards (44.5 percent) were not achieved at the end of the intended monitoring periods. Finally, using the *Washington State Wetlands Rating System* (Ecology 1993), this study determined the Department's mitigation efforts provided a net gain in higher quality Category II wetlands (14.43 acres) in exchange for a net loss in lower value Category III and Category IV wetlands (19.11 acres). These results suggest WSDOT has been effective at replacing lower rated wetlands impacted by highway improvement projects with wetlands of higher ratings. This study provides the following recommendations to improve permit compliance and environmental success: (1) a comprehensive set of design standards should be developed that will address all aspects of wetland mitigation, (2) roles and responsibilities of WSDOT wetlands staff should be clearly defined to assure that those with the necessary technical expertise have the authority to make decisions, and (3) open discussions with regulatory staff should occur to establish functions-based success standards that are reasonable and achievable within the designated monitoring period.

***Key Words*:** wetland mitigation, permit compliance, and monitoring data analysis.

INTRODUCTION

Construction of new highways, highway interchanges, and bridges accompany economic and population growth in the state of Washington. The Washington State Department of Transportation (WSDOT, or the Department) routinely evaluates the effects of these transportation improvement projects on wetlands. When efforts to avoid or minimize

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impacts to wetlands are not possible, compensatory wetland mitigation may be considered as a final option. While WSDOT continuously strives to increase the effectiveness of its compensatory wetland mitigation sites, the Department recognizes changes can be made to improve permit compliance and the environmental success of these mitigation efforts.

Several regional and national studies suggest net loss of wetland area and function occurs when mitigation efforts fail to fully compensate for impacts to wetlands (Gwin and Kentula 1990; Mockler et al. 1998; NRC 2001). In the absence of strong regulatory oversight, some mitigation sites have never been constructed (Redmond 1992; Race and Fonseca 1996; Brown and Veneman 2001), while other sites fail to compensate for what was lost from project impacts (Storm and Stellini 1994; Gwin et al. 1999; Magee at al. 1999). Poor site selection, failure to establish adequate wetland hydrology, inadequate follow-up monitoring, unsuccessful plant establishment, weed infestations, lack of active site management, and insufficient compliance monitoring have been identified as causes of mitigation site failure (Mitsch and Wilson 1996; Shank 1997; Johnson et al. 2000, 2002). These and other studies indicate a need for further evaluation of the effectiveness of compensatory wetland mitigation (Harwell et al. 1999; La Peyre et al. 2001).

An evaluation of the effectiveness of WSDOT wetland mitigation projects has not been conducted since 1996. In the interim, changes have occurred in our understanding of wetland science, mitigation site design, and the regulatory environment. Improvements have been made in many aspects of the mitigation process from pre-construction planning to post construction monitoring and adaptive management. Further evaluation seems necessary to gauge the Department's current success in meeting state mandates for wetland mitigation.

In terms of permit compliance, this analysis provides an objective evaluation of the effectiveness of compensatory wetland mitigation efforts at WSDOT. Specifically, this study evaluates the Department's success in meeting wetland acreage requirements, achieving site success standards (also known as "performance measures" or "success criteria"), and replacing wetland functions using wetland ratings as a surrogate for function evaluation. Information from this report is intended to inform and improve the Department's mitigation efforts statewide. Results from this study will provide a complement to the Department's goals of consolidating information and tracking environmental compliance.

Background

Wetland mitigation incorporates a series of sequential steps designed to eliminate, reduce, or compensate for impacts to wetlands. The mitigation process begins with impact avoidance, proceeds to impact minimization, and continues to compensation when impacts to wetlands are unavoidable (Memorandum of Agreement 1990). Compensation may include one or a combination of the following mitigation strategies: wetland creation (i.e., establishment), restoration (i.e., re-establishment/rehabilitation), enhancement, and preservation (protection) (Federal Register 1995; USACE 2002).

Thirty compensatory mitigation sites incorporating a combination of wetland creation, restoration, enhancement, and preservation strategies are included in this study. Sites from this study fall into two general wetland classes as defined by Cowardin et al. (1979). Twenty-eight are palustrine emergent, scrub-shrub and/or forested wetlands, and two are estuarine emergent wetlands. As described by Omernik and Gallant (1986), 21 of these sites lie within the Puget Lowland Ecoregion, seven within the Willamette Valley Ecoregion, one in the Coast Range Ecoregion, and one in the Columbia Basin Ecoregion.

Only permitted wetland mitigation sites with formal monitoring and reporting requirements are included in this evaluation. Sites in this study were permitted from 1991 to 1997 and constructed in the mid- to late-1990s. All 30 sites completed their intended monitoring periods from 2000 to 2003 and were surveyed by biologists from the Department's Wetland Assessment and Monitoring Program. This sample includes one site with a three-year monitoring period, one with an eight-year period, and 28 with a five-year monitoring cycle.

Information to support this study was assembled from the Department's mitigation site monitoring files. These files typically include monitoring reports, data records, pre-impact biology/wetland reports, mitigation plans, planting plans, and copies of site regulatory permits. As-built plans were available for six of the 30 sites included in this study. While wetland delineations, functions assessments, and final-year evaluations of site-specific success standards were performed as part of routine site monitoring activities, wetland ratings were conducted specifically for this analysis.

METHODS

Wetland Acreage

Net wetland acreage gain for the 30 sites included in this study was determined by comparing results from wetland delineations conducted on the impact sites prior to project construction to delineation results completed on the mitigation sites after the final monitoring year. Department biologists used methods described in the *Washington State Wetlands Identification and Delineation Manual* (Ecology 1997) and a Global Positioning System (Trimble TSCI data logger) to identify and record wetland boundaries in the field.[4] A geographic information systems specialist processed the collected data, and a wetland delineator reviewed the resulting polygons for accuracy.

Success Standards

Objectivity in interpreting monitoring results was considered essential. To accomplish this goal, methods were used to minimize bias and ensure repeatability. Quantitative methods were used to address site success standards unless qualitative techniques were judged more appropriate.

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[4] Delineation methods in the Ecology (1997) manual are consistent with those described in the *Corps of Engineers Wetlands Delineation Manual* (USACE 1987).

As required by regulatory permits or the mitigation plan, 173 final-year success standards were evaluated for 29 of 30 sites included in this study. No success standards were written into the plan or permits for one site evaluated for this study. Therefore, this site was excluded from this phase of the evaluation. In addition, for eight success standards that were judged immeasurable or ambiguous, results were recorded as "inconclusive" and these standards were excluded from this study. For example, plant mortality and natural recruitment often confound survival estimates made long after trees and shrubs are planted. In general, survival estimates cannot be made with any reasonable level of accuracy or precision three to five years after plant establishment. These and similar standards were considered not measurable and results were recorded as "inconclusive." Where plant survival assessments were completed, results were recorded as "qualitative," only.

Plant Cover. When sampling was required to determine success standards conformance for herbaceous and woody species plant cover, objective data collection and statistical analysis techniques were employed. For the herbaceous plant community, the point-line and point frame methods (Bonham 1989; Coulloudon et al. 1999) were used to collect aerial cover data. With these methods, a vertical rod or pin flag was lowered from above the tallest vegetation. All plant species intercepted by the rod or pin were recorded. Cover estimates were calculated by dividing the number of times target vegetation was encountered (drops of the pin or rod) by the total number of points per frame or point-line sample unit. For trees and shrubs, aerial cover data were collected using the line-intercept method (Bonham 1989; Elzinga et al. 2001). Using this technique, woody vegetation intercepting a line (the sample unit) was identified and the length of each canopy intercept was recorded. The sum of the canopy intercepts was divided by the total length of each line-segment sample unit to calculate an aerial cover value.

For estimates of invasive or noxious species cover, the *State Noxious Weed List* (Washington State Noxious Weed Control Board 2003) was used to identify county-specific noxious weed species. Other nuisance or invasive species were included in these estimates. These species were *Rubus armenicaus* (Himalayan blackberry), *Rubus laciniatus* (evergreen blackberry), *Dipsacus fullonum* (Fuller's teasel), *Sonchus asper* (spiny sowthistle), and *Solanum dulcamara* (bitter nightshade).

Using these techniques, sample units (point-lines, point frames, or lines) and sampling transects were randomly positioned across the target plant population using simple, stratified, systematic, or restricted random methods. Sample units and transects were aligned along the primary environmental gradient using methods described in Krebs (1999), Elzinga et al. (2001), and Radar et al. (2001).

For herbaceous and woody plant species cover data, sample size analysis was able to confirm sufficient sampling had been completed based on sampling objectives and whether the desired level of statistical confidence was achieved. The following equation for estimating a single population mean with a specified level of precision was used to perform this analysis (Zar 1999; Elzinga et al. 2001).

$$n=\frac{(Z_\alpha)^2(s)^2}{(B)^2}$$

Z_α = standard normal deviate
s = sample standard deviation
B = precision level
n = unadjusted sample size

In this equation, the precision level (B) equals half the maximum acceptable confidence interval width multiplied by the sample mean.

A sample size correction to n was necessary to adjust "point-in-time" parameter estimates (Kupper and Hafner 1989; Elzinga et al. 2001). The adjusted n value reveals the number of sample units required to report the estimated mean value at a specified level of confidence.

Plant Diversity and Vertical Stratification. Plant diversity and vertical stratification were measured using species counts, cover estimates, site photography, or height measurements as indicated by the requirements of site-specific success standards. A survey rod and photographs were used to qualitatively document vertical stratification in the wetland plant community unless quantitative techniques were judged more appropriate. To quantitatively assess plant community stratification, heights of individual trees and shrubs were estimated to the nearest 0.5-meter along line-segment sample units randomly positioned across the target area. A two-tailed *t*-test assuming unequal variances ($\alpha = 0.05$) was completed to determine if a significant difference between shrub and tree heights was present in the woody species canopy.

Wildlife Habitat and Species Diversity. Wildlife standards were addressed through documentation of species presence, counts of habitat structures (e.g., snags, brush piles, root wads), and habitat observations or assessments, as appropriate. When quantitative methods were deemed appropriate to assess avian species richness and diversity, point counts were conducted to record species numbers and relative abundance (Ralph et al. 1993). Species diversity indices (H) were calculated from bird survey data using the Shannon-Wiener function (Krebs 1999; Nur et al. 1999). Results were expressed as a mean annual species diversity index.

$$H' = -\sum_{i-1}^{s}(p_i)(\log p_i)$$

H' = index of species diversity
s = number of species
p_i = sample proportion belonging to the *i*th species

The following *t*-test was used to test the null hypothesis that diversity indices from different years are equal (Zar 1999).

$$t=\frac{H_1^{'}-H_2^{'}}{S_{H_1^{'}-H_2^{'}}}$$

$H^{'}$ = index of species diversity
$S_{H_1^{'}-H_2^{'}}$ = standard error of the difference in diversity indices

Water Regime and Wetland Soils. Primary and secondary field indicators were recorded to document presence of wetland hydrology and to aid in delineation efforts. Primary field indicators include visual observation of inundation or saturation, watermarks, drift lines, sediment deposits, and presence of drainage patterns within the wetlands. Secondary field indicators of wetland hydrology include presence of oxidized rhizospheres, presence of water-stained leaves, and local soil survey hydrology data for identified soils (USACE 1987). Soil texture and composition analysis were completed in a laboratory to address the only wetland soil success standard included in this evaluation.

Site Development According to Plan. Mitigation and planting plans were used in combination with site visits to determine whether site construction was consistent with the original plan. As-built plans were used when available.

<u>Wetland Rating</u>

While replacement of wetland functions is the underlying goal of wetland mitigation projects; incomplete records, inconsistent terminology, and different or poorly described functions assessment methods made it impossible to compare functions lost from project impacts to functions gained through mitigation. There is still much discussion and little agreement on the relative value of various quantitative and semi-quantitative functions assessment methods in the state of Washington. Therefore, the *Washington State Wetlands Rating System* (Ecology 1993) was used instead of a more specific indicator of wetland function because there has been broad agreement on its use and application. Pre-construction impact sites and mitigation sites were placed into wetland categories using this system. Only wetland creation and restoration acreage were included in this analysis.

In most cases, ratings information for the impacted wetlands was contained in the pre-construction biology/wetland report or site mitigation plan. However, this information was not available for six pre-impact sites that were evaluated before the Ecology (1993) rating system gained widespread application. Ratings were developed for three of these six sites based on information contained in the mitigation plan, pre-construction biology/wetland report, or from the evaluating biologist's personal knowledge of the impact sites. While this information was sufficient to provide accurate wetland ratings for these three sites, incomplete data records eliminated the three oldest sites from this phase of the evaluation.

To support findings from the wetland ratings data set, a qualitative functions assessment was completed for all mitigation sites included in this phase of the study. The *Wetland Functions Characterization Tool for Linear Projects* (Null et al. 2000) was used to perform these assessments. Results were compared to information from the wetland ratings data set. The following functions were evaluated: flood flow alteration, sediment removal, nutrient and toxicant removal, erosion and shoreline stabilization, organic matter production and export, general habitat suitability, habitat for aquatic invertebrates, amphibian habitat, wetland associated mammals and birds, general fish habitat, native plant richness, educational or scientific value, and uniqueness and/or heritage.

RESULTS

Wetland Acreage

For the 30 sites included in this evaluation, 100.86 acres of wetland mitigation were required for 47.06 acres of unavoidable wetland impacts that occurred as transportation improvement projects were completed. The Department successfully provided 92.33 acres (91.5 percent) of wetland creation, restoration, enhancement, and preservation as compensation. Evaluated on a project-by-project basis, 14 (46.7 percent) of 30 mitigation sites attained or exceeded their required wetland mitigation acreage. Mitigation site construction did not conform entirely to plan for 13 of the 16 sites that did not meet acreage requirements, which resulted in the creation of an insufficient amount of wetland area. For three sites, inadequate wetland design appears to be primarily responsible for the lack of sufficient wetland acreage.

Twenty-seven of the 30 sites reviewed for this evaluation had complete and detailed records from which pre-impact wetland acreage information could be extracted for comparison (Figure 1). For these 27 sites, regulatory permits required the agency to

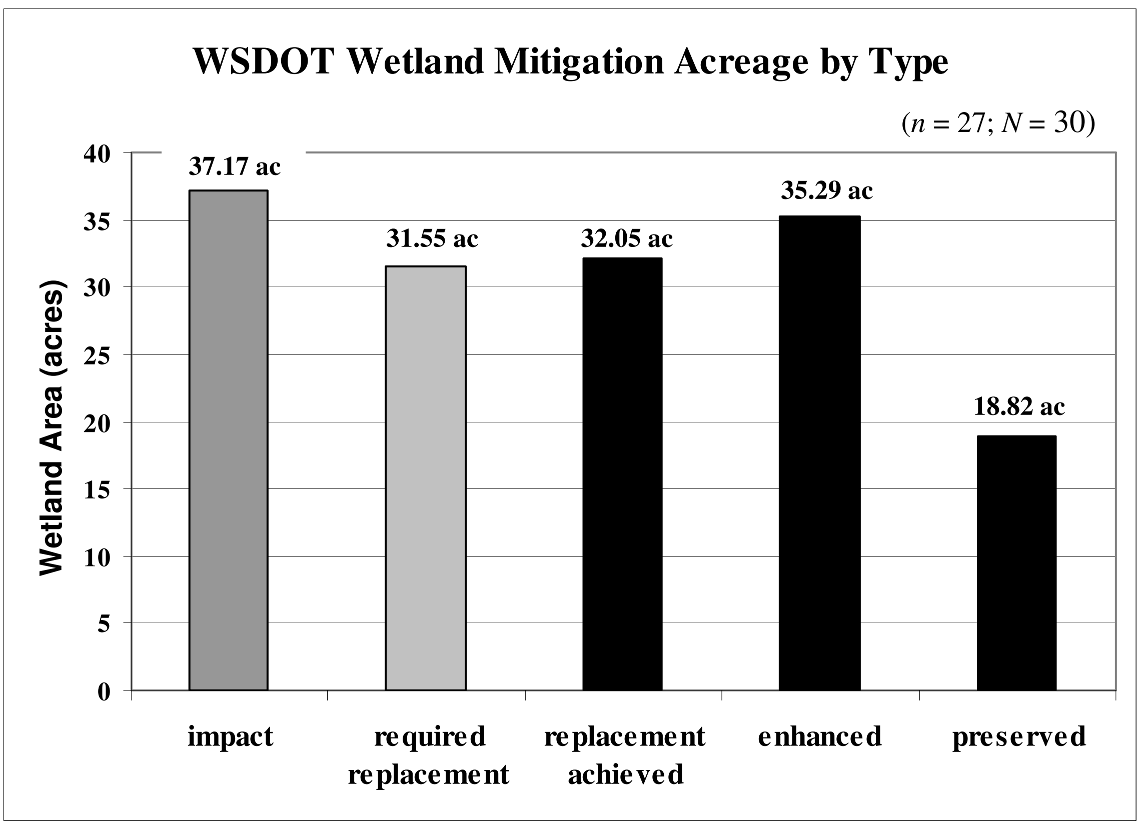

Figure 1: Figure 1 shows 86.16 acres of wetlands were created, restored, enhanced and preserved as compensation for 37.17 acres of project impacts for the 27 sites in this sub-sample. In this figure, replacement acreage is equivalent to acres of creation and restoration, combined.

create or restore 31.55 acres (replacement acreage). Delineations completed at the end of the initial monitoring period show 32.05 acres of wetland (enhancement acreage excluded) were established as replacement, exceeding regulatory requirements by 0.50 acre. The required 31.55 acres of wetland replacement is 5.62 acres less than the 37.17 acres of impact. This difference is due, in part, to an agreement with regulatory agencies that authorized 15.00 acres of enhancement and 10.00 acres of preservation as mitigation for 9.60 acres of wetland impacts for a project permitted in 1991. Additional mitigation at these 27 sites includes approximately 20 acres of wetland enhancement and 9 acres of wetland preservation. Figure 1 provides a summary.

Information separating enhancement from creation acreage was not available for three mitigation sites permitted in 1992, which prevented their inclusion in the data set above. For these sites, records indicate 15.74 acres of wetland creation and enhancement were required as compensation for 9.89 acres of project impacts. A delineation completed at the end of the initial monitoring period identified only 6.17 acres of wetland mitigation, a deficiency of 9.57 acres from the acreage required for these projects. This deficiency represents a loss of at least 3.72 acres of wetland. Remediation plans are proposed for these three mitigation sites in the 2005 construction season.

Wetland buffers are present on all sites included in this study, and they appear to conform closely to the plan sheets. On many sites, buffer impacts were also mitigated, but are not discussed in this evaluation.

Success Standards

Success standards were written for 29 of the 30 mitigation sites included in this study. For these 29 mitigation sites, 173 of 181 final-year success standards were evaluated. The eight standards that were excluded from this evaluation were considered immeasurable or ambiguous, and monitoring results were recorded as "inconclusive."

Monitoring data analysis indicates 96 standards (55.5 percent) were achieved, while 77 standards (44.5 percent) were not achieved at the end of the intended site monitoring periods (Table 1). Success in meeting site success standards was evaluated for each

Year Monitoring Cycle Complete	**Number of Sites**	**Number of Standards**	**Standards Achieved**	**Standards not Achieved**	**Percent Success**
2000	5	20	12	8	60.0
2001	12	88	50	38	56.8
2002	5	22	13	9	59.1
2003	7	43	21	22	48.8
Totals	**29**	**173**	**96**	**77**	**Mean = 55.5%**

Table 1: Table 1 summarizes success in meeting standards for the 29 mitigation sites included in this phase of the evaluation. Calculated on an annual basis, success rates range from 48.8 percent in 2003 to 60.0 percent in 2000.

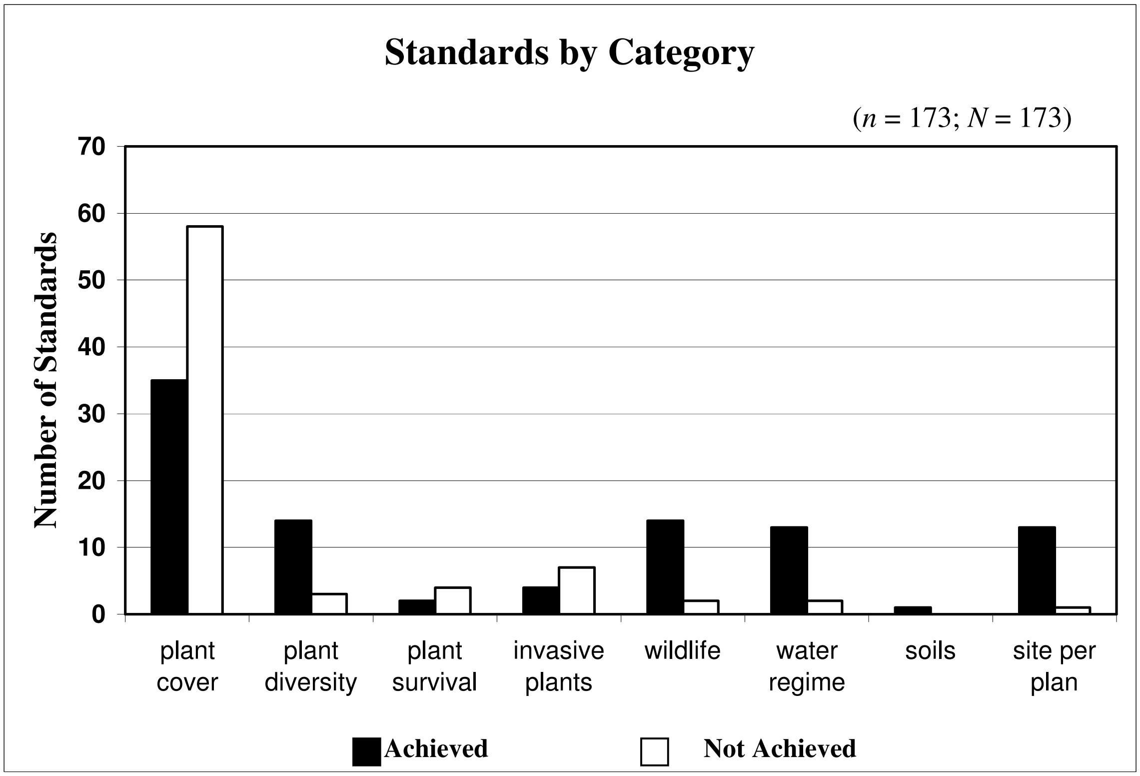

Figure 2: Figure 2 shows standards separated by category. Standards for plant diversity, water regime, soils, wildlife, and site development were more frequently achieved than standards for plant cover, plant survival, and invasive species.

monitoring year. Table 1 provides a summary of these results.

The 173 success standards included in this evaluation can be separated into several general categories. These categories are: plant cover, plant species diversity, survival of plantings, invasive species cover, wildlife habitat (structures and use), water regime, wetland soils, and site construction according to plan (Figure 2). Based on findings of this analysis, vegetative cover targets (primarily tree and shrub cover standards) and invasive species cover thresholds appear to be the most difficult standards to achieve. Standards for plant species diversity, wildlife habitat, water regime, and site development consistent with the mitigation plan were achieved in most cases. However, only the standard for soils achieved 100 percent success.

Sixteen of 29 sites (55.2 percent) met at least half their standards after completion of the monitoring period, while 13 sites (44.8 percent) met less than half their standards in the final monitoring year (Figure 3). Only one site included in this study met 100 percent of its success standards. To facilitate the achievement of success standards and compliance, an extended monitoring period and site remediation plans have been initiated for 20 of the sites that did not meet all standards. Additional management activities are not presently planned for the eight remaining sites. Instead, these sites have been allowed

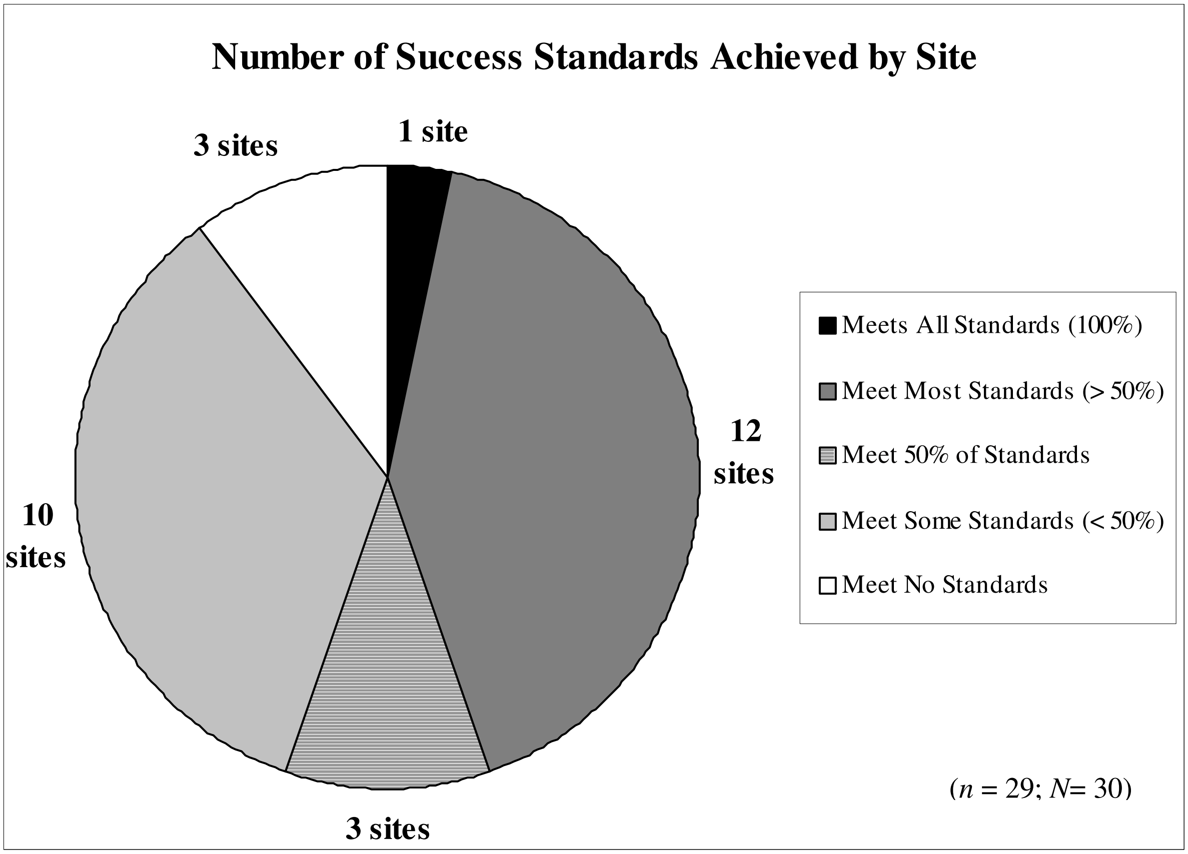

Figure 3: Figure 3 shows one site met all of its standards, and 16 sites met at least half their standards. The remaining 13 sites met less than half their standards.

more time to develop. As necessary, monitoring and adaptive management will continue until these sites are judged to be successful in meeting regulatory commitments.

Wetland Rating

Wetland ratings were developed for 27 of 30 sites included in this study. Incomplete data records eliminated three of the oldest sites from this phase of the evaluation. These sites were permitted in 1991, two years before the *Washington State Wetlands Rating System* (Ecology 1993) received widespread application.

Looking at just wetland creation and restoration acreage (replacement acreage), the 27 mitigation sites included in this phase of the study have resulted in a net gain in higher value Category II wetlands (14.43 acres) and a net loss in lower value Category III and Category IV wetlands (19.11 acres) (Figure 4). Impacts to Category I wetlands (0.73 acres) were recorded for three projects from this sample. Although one of these projects successfully restored 0.35 acres of Category I wetland, small size and location prevented the other two projects from receiving the same result. These results indicate that for many projects, the Department has effectively replaced lower rated wetlands with wetlands of higher value. Figure 4 provides a summary.

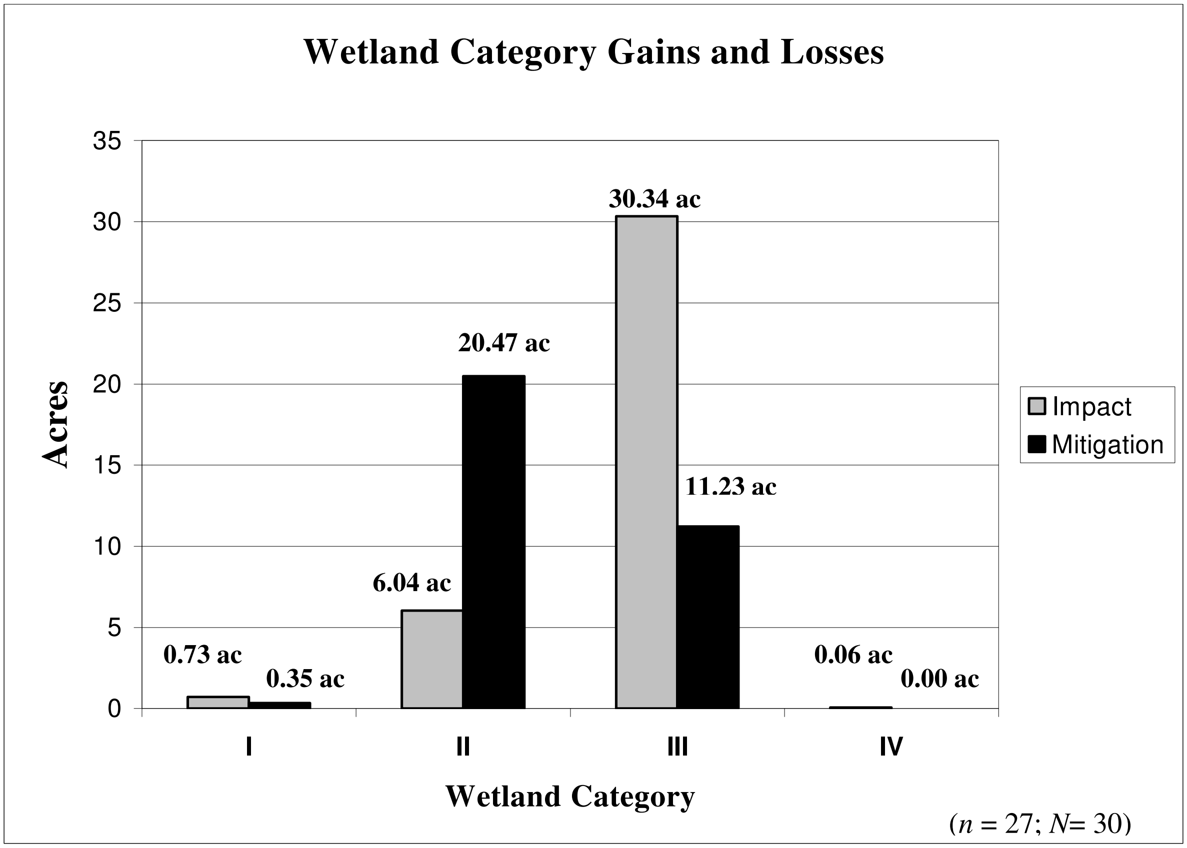

Figure 4: Figure 4 shows replacement wetland creation and restoration acreage by wetland category. A net gain in Category II wetland acreage compares to a net loss in Category III wetland acreage.

DISCUSSION

While "no net loss" of wetland functions is the underlying goal of wetland mitigation (Executive Order 89-10; NRC 2001; USACE 2002), wetland functions are generally complex and not easily measured. Few quantitative wetland functions assessment methods currently exist that are both scientifically valid and applicable in a regulatory context (Mitsch and Gosselink 2000; Kusler 2004). Therefore, wetland size and type are often used as surrogate goals for function replacement. To further define these goals, performance measures, which in many instances are field indicators of wetland functions, are generally established for each mitigation site to set measurable benchmarks to gauge success. Consequently, three questions were asked for each of the mitigation sites evaluated in this study: (1) Does the mitigation site provide the required wetland acreage? (2) Has the mitigation site achieved its success standards? (3) Has the mitigation effort effectively replaced the impacted wetlands with a wetland of equal or higher value?

Documentation Deficiencies

The 30 mitigation sites included in this study were permitted from 1991 to 1997 and constructed in the mid- to late-1990s. Not surprisingly, documentation and planning for many of the older projects we evaluated were insufficient by present standards. These deficiencies included site records with multiple copies of revised mitigation plans and incomplete or confusing site documentation. We found final mitigation plans were not always clearly marked to distinguish them from earlier iterations. In one case, only a conceptual mitigation plan was available. To avoid confusion, we believe all draft copies of the mitigation plan should be eliminated from site records and only an approved final version of the plan should be retained. In addition, permits and mitigation plans often contained unclear or conflicting wetland impact and mitigation acreage information. Simple mathematical errors were responsible for confusion in several of the mitigation plans. For three sites, mitigation plans did not separate planned wetland enhancement from creation or restoration acreages.

Post-construction as-built plans were found for only six of 30 sites included in this evaluation. Based on findings from this and other studies (Gwin and Kentula 1990; Johnson et al. 2000), we believe as-built plans should be developed with the assistance of a trained wetland scientist for every WSDOT mitigation project. These plans provide a baseline for monitoring and a means to document changes with permitting agencies. Flexibility to make changes during the development of a wetland mitigation site is critical. However, a mitigation site may appear to be out of compliance if authorized changes are not clearly illustrated in the as-built plan (Kentula et al. 1992; Storm and Stellini 1994) or other project documentation. For the 24 sites without this documentation, it was difficult to determine whether site construction had actually occurred according to plan.

Lack of consistent methods and vocabulary made comparison of pre-impact and post-construction wetlands assessment data difficult to analyze. Pre-impact functions assessment techniques were sometimes poorly or incompletely described. As a result, it was often impossible to evaluate how well mitigation sites replaced wetlands lost during the development of transportation improvement projects. Results from this and other studies (Morgan and Roberts 1999; NRC 2001) suggest a higher level of integration and coordination among all phases of the mitigation process is desirable. Staff involved in pre-impact site assessments, mitigation site design, and monitoring should use similar vocabulary and methods when appropriate and practicable. Improvement is expected as new methods of wetland assessment (Null et al. 2000; Hruby 2004a, 2004b) are applied more consistently by WSDOT.

Some positive trends were noted during file reviews conducted for this study. Recent changes in the documentation process have improved site record keeping for some past and all current mitigation projects. The Department's Wetland Assessment and Monitoring Program now acts as a repository for mitigation site records. Each year project permits, final mitigation plans, pre-impact wetland/biology reports, as-built planting plans, grading plans, and hydrology monitoring data are compiled for all new mitigation projects with formal monitoring and reporting requirements. To complement and support these efforts, an electronic storage and environmental compliance tracking system is in the early stages of development. These changes have already improved site documentation and record keeping at WSDOT.

Wetland Acreage

Although results from this evaluation indicate WSDOT's mitigation sites often replace the required wetland area, these findings also demonstrate that the Department's efforts are not always successful. Records show 16 (53.3 percent) of 30 mitigation sites in this study did not achieve the required wetland acreage. Eight of these 16 sites missed acreage requirements by less than 0.3 acre, while five sites missed requirements by more than one acre. The three remaining sites missed acreage requirements by less than one acre, but more than 0.5 acre. Reasons for these shortcomings include poor site selection, improper site design, poor site preparation, inadequate site management practices, and insufficient follow-through.

From site records and findings of this study, we believe site selection is one of the most important factors in determining site success. In the past, there has been some reluctance to devote the energy and finances needed to assure that adequate sites for the Department's wetland mitigation projects were obtained. Records show site selection has not always been based on ecological considerations. In this study, nine of the 30 mitigation sites we evaluated were constructed within the highway right-of-way on small plots of land adjacent to the construction or project impact area. While property ownership made site selection within the highway right-of-way an attractive option for WSDOT, major excavation was often required at high cost to create suitable wetland hydrologic regimes. Sometimes grading and excavation were sufficient to produce adequate wetland hydrology and acreage, but for five of the nine mitigation sites constructed in the highway right-of-way, they were not. Consistent with results from other studies (Confer and Niering 1992; Mitsch and Wilson 1996; Gallihugh and Rogner 1998), we found some sites immediately adjacent to the highway were subject to excessive water level fluctuation and prolonged inundation making plant establishment difficult, or impossible. On many sites, soils within the highway right-of-way were inadequate to support growth of wetland plants without significant and costly soil amendments. We identified problems associated with soil compaction from heavy construction machinery, lack of sufficient space for wetland buffers, and adjacent land-use conflicts. As land use intensifies, especially in highly urbanized environments, locating suitable sites for compensatory mitigation becomes increasingly difficult. However, we believe a careful site selection process that is based on ecological as well as fiscal and property ownership considerations will undoubtedly improve the Department's mitigation site success. Some environmental offices at WSDOT now prohibit use of the highway right-of-way for wetland mitigation.

While federal guidelines have expressed a preference for on-site and in-kind mitigation (NRC 2001; USACE 2002), recent studies suggest site selection should be based primarily on watershed-level needs and the potential for mitigation site success (Scodari and Shabman 2001; Marble and Riva 2002). Research shows proper mitigation site placement within hydrogeologic and climatic settings is necessary to ensure wetland sustainability (Bedford 1996; Mitsch and Gosselink 2000). In general, watershed-level needs have not been considered during the site selection process at WSDOT. This has been due, in part, to a lack of coordination between regulatory staff, watershed planners, and WSDOT mitigation site designers. Transportation project costs and timelines sometimes make establishing these relationships difficult. Stronger and more consistent support within and between state and federal regulatory agencies and WSDOT for alternatives to on-site, in-kind mitigation will encourage selection of sites that are more amenable to wetland mitigation. Benefits from careful site selection may include a reduction in short and long-term costs, as the need for costly site preparation and remediation efforts are reduced.

In addition to poor site selection, improper site design and site preparation were identified as probable sources of project nonconformance for several mitigation sites from this study. For example, three sites permitted in 1992 may have failed to achieve a significant portion of their intended wetland mitigation acreage because grading plans were designed too shallow to provide appropriate wetland hydrology. The hydrologic regimes that developed were insufficient to support the intended cover of wetland vegetation. Soils compacted during site construction may have contributed to these deficiencies. For these three sites, records indicate 15.74 acres of wetland creation and enhancement were required for 9.89 acres of project impacts. A delineation at the end of the intended monitoring periods identified only 6.17 acres of wetland mitigation, a deficit of 9.14 acres from permit requirements and a loss of at least 3.72 acres of wetland. Site remediation plans scheduled for the 2005 construction season include re-grading areas of these three mitigation sites to establish the intended hydrologic regimes, and soil amendments to facilitate plant establishment.

Inadequate site management practices and insufficient follow-through were responsible for mitigation site nonconformance on several other projects from this study. A mitigation site permitted in 1993 was located in the confines of a highway off-ramp. Since site construction occurred in an area with no surface water and piezometer readings showed the water table was 13 to 15 feet below the surface, precipitation was identified as the project's primary source of wetland hydrology. However, only 0.01 acre of wetland developed on this site due to the installation of an ineffective clay liner that was designed to retain water. Though monitoring revealed the problem soon after site establishment, the clay liner was never replaced or repaired. As a result, this mitigation project created almost none of the required 1.64 acres of wetland area. Given these and similar observations, we believe monitoring data could be used more effectively to inform site management and maintenance activities. In this case, problems with the clay liner may have been avoided with more thorough on-site inspections during the construction process. Additionally, improved communications and follow-through may have corrected this problem during an early stage of site development. In a positive sign, a new communication and reporting mechanism between the Department's environmental offices and monitoring field staff was developed in 2002. WSDOT monitoring program staff now track site management activities. Follow-up is provided whenever it is needed.

For 27 of 30 sites included in this study, records indicate 32.05 acres of wetland were established as replacement (restoration and creation acreage) for 37.17 acres of project impacts. These results indicate a loss of more than five acres of wetland. However, this loss in acreage is due, in part, to an agreement with regulatory agencies that authorized 15.00 acres of wetland enhancement and 10.00 acres of preservation as mitigation for 9.60 acres of wetland impacts for a project permitted in 1991. Loss of wetland area has often been authorized as part of the regulatory permitting process (Kunz et al. 1988; Kentula et al. 1992; Sibbing 1997). Nonetheless, it is doubtful this project would be permitted in a similar manner today.

Success Standards

Streever (1999) defines success standards as observable or measurable attributes that can be used to determine if a compensatory mitigation project meets its objectives. While it is clear that standards must be observable or measurable to be effectively addressed through monitoring, MacDonald et al. (1991) and Elzinga et al. (2001) argue standards must be meaningful and achievable, as well. Based on findings of this study, we believe success standards and permit requirements that cannot reasonably be achieved within a specified timeframe are common reasons for not meeting site success standards.

Azous et al. (1998) suggest monitoring data can be used to formulate a more meaningful and achievable set of success standards for future mitigation projects. We agree mean and median values for measured site attributes can be used to set targets that are achievable in specified timeframes. However, we found wide physical, biological, and hydrological variability among sites evaluated for this study. In accordance with findings from other studies, we believe environmental conditions and project location should always be considered when setting site-specific success standards (Mitsch and Gosselink 2000; NRC 2001; Sammans 2002). Targets should be adjusted accordingly. Our analysis of wetland woody and invasive species cover data provide just two examples.

Wetland Woody Cover. Rapid growth and a direct response to environmental change make trees and shrubs reliable indicators of wetland health and condition (Azous et al. 1998; USEPA 2002). For these reasons, performance criteria that require specific levels of tree and shrub canopy cover are frequently included in the success standards or permit requirements of site mitigation plans.

Success standards that require 70 to 80 percent woody species cover in the wetland five years after plant establishment were included in site permit requirements and mitigation plans for more than one third of the sites included in this evaluation. We believe these targets are not reasonable and achievable based on findings from this and other studies. For example, Cassatt (1998) found high plant densities are required in the Pacific Northwest to produce greater than 40 percent wetland woody species cover three years after planting. For large mitigation sites, high planting densities are expensive and may be a waste of plant material over the long term, as individual trees and shrubs compete with one another five to ten years after planting. Celedonia (2002) found woody species cover targets of 80 percent could not be reliably achieved until 8 years after planting for

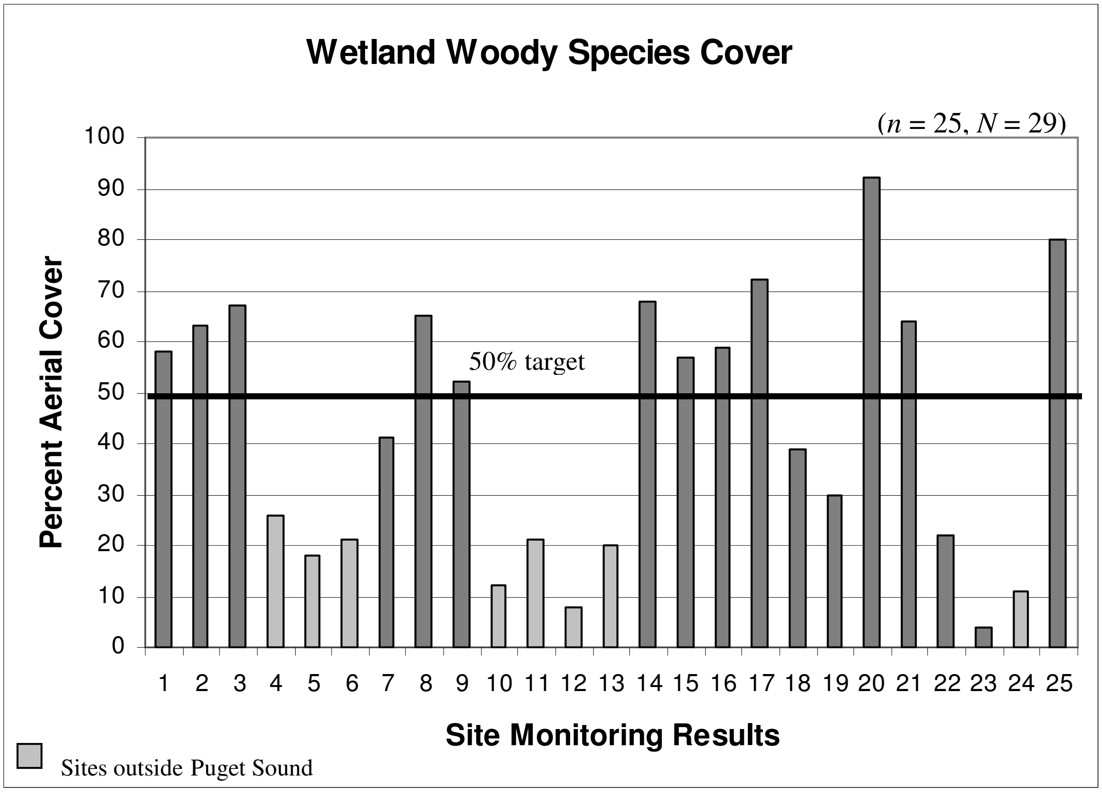

Figure 5: To address final-year success standards and permit requirements, cover values for wetland trees and shrubs were estimated for 25 of 30 sites included in this study. Light gray shading identifies sites located outside the Puget Sound Ecoregion.

wetland trees and shrubs in the lowlands of Puget Sound. This study also suggests high planting densities (≥ 3,000 stems/acre) may contribute to rapid establishment of canopy cover. However, the author cautions, high stem densities may inhibit development of other desirable features in the tree and shrub community including plant maturity, emergence of a forest canopy, and vertical stratification. Data from these studies are consistent with findings from our evaluation.

Twenty-five of the 29 sites included in this phase of the analysis had final-year success standards for wetland woody cover that could be used for comparison. Only three sites, all located in the lowlands of Puget Sound, met or exceeded the 70 percent threshold for woody species cover 5 years after planting (Figure 5). Sites located in drier or higher elevation areas away from Puget Sound had substantially less than 50 percent wetland woody species cover after five years. These results are summarized in Figure 5.

We calculated mean and median cover values for all sites in this data set ($\overline{X}$ = 43%; median = 41%; s = 26%). These results indicate that, in general, five-year targets for wetland woody species cover are set too high. Looking at just those sites in the Puget Sound Ecoregion (n = 17), these data suggest a target of 50 percent wetland woody species cover may be more reasonable and achievable five years after planting in this region ($\overline{X}$ = 55%; median = 59%; s = 22%). Moreover, data from this study suggest that targets for woody vegetation cover should be set even lower for drier or higher elevation sites in the Coast Range, Willamette Valley and Columbia Basin Ecoregions.

Based on the findings of this and other studies (Azous et al. 1998; Streever 1999; NRC 2001), we believe a stronger link should be made between site goals, objectives, and success standards. In some cases, we found woody cover standards used to evaluate mitigation site success did not appear to be strong indicators of wetland function or site performance. For example, one of the mitigation sites investigated for this study showed positive development in nearly all respects over its designated five-year monitoring period. Wetland plant communities are well established and appear to reflect site goals and objectives. Native trees and shrubs dominate the site's scrub-shrub and forest canopies with 16 species present in the data record. A diverse, native emergent plant community has developed along seeps that flow from side slopes into a perennial wetland pond and stream. Monitoring data analysis shows this site supports just 9% ($CI_{90\%}$ = 7-11%) cover of invasive species, a relatively low cover value for undesirable plant species compared to other sites in the region.[5] A qualitative assessment of wetland functions conducted at the end of the designated monitoring period suggests this site provides all of its intended functions including water storage and attenuation, sediment and nutrient trapping, wildlife habitat, and food chain support functions. Still, with only 64% ($CI_{90\%}$ = 54-73%) wetland woody cover, this site does not meet three of its four final-year success standards (i.e., 80 percent cover of native, wetland woody species) and has not been judged a regulatory success. More time may allow the woody species canopy to increase coverage. However, a larger than anticipated emergent zone has developed on this site, and it seems doubtful the scrub-shrub and forest canopies will meet the 80 percent cover target.

Similar results were recorded for several other sites in this study. While we agree tree and shrub growth provide a measure of wetland health and condition, we believe success standards for woody cover should not be used as the only gauge of site performance in most cases. Evidence suggests success standards for woody cover are generally a poor indicator of wetland function (Reinartz and Warne 1993; Mitsch and Wilson 1996; Brown and Veneman 2001) and they do not always provide a meaningful measure of wetland success. In 2003, WSDOT initiated discussions with regulatory agencies to mutually establish functions-based success standards that satisfy the goals of wetland mitigation. To be a useful gauge of mitigation site success, these standards must be both meaningful and achievable in the specified monitoring period.

Although high value targets for woody species cover made success standards difficult to achieve for many mitigation projects in this study, poor site selection and unpredictable wetland hydrology were responsible for site nonconformance in some cases. For example, seven of nine sites constructed in the highway right-of-way did not meet final-year success standards for woody cover. In each case, impervious pavement and steep side slopes likely produced excessive stormwater inflows and a flashy hydrologic regime

[5] Estimated values are presented with their corresponding statistical confidence interval. In this case, 9% ($CI_{90\%}$ = 7-11%) means we are 90 percent confident that the true aerial cover value is between seven and 11 percent cover.

over the monitoring period. Monitoring records suggest excessive water level fluctuations may have contributed to slow plant establishment and the low levels of woody cover observed after five years of site development.

Invasive Species Cover. Eight of 29 sites included in this phase of the evaluation had success standards for invasive species cover. Six of these eight sites had an invasive species cover threshold of just 10 percent. Based on the findings of this study, we believe a threshold of 10 percent invasive species cover is not reasonable or achievable for most mitigation projects.

For sites located in highly disturbed or degraded urban environments, we believe invasive species cover targets should be set higher. For example, one site evaluated for this study is located in a highly developed urban watershed and is bordered on three sides by fields of reed canarygrass (*Phalaris arundinacea*). Reed canarygrass is a highly invasive grass species common to disturbed emergent, scrub-shrub, and forest wetlands in the Pacific Northwest. A stream that runs the length of the mitigation site is sediment laden and water quality appears to be poor. Studies suggest it is likely these conditions have contributed to the high levels of reed canarygrass observed on this mitigation site (Magee et al. 1999; Azous and Horner 2001; Maurer et al. 2003). Monitoring data indicates this site presently supports 68% ($CI_{90\%}$ = 60-76%) cover of reed canarygrass. A success standard that requires no more than ten percent cover of invasive species for this site will be impossible to meet given present site conditions and location. In this case, poor site selection makes successful wetland development difficult.

While high levels of invasive species cover may have an effect on overall site performance, attempts to maintain extremely low levels of invasive species cover can have undesirable consequences for the mitigation project, as well. It is evident that costs in terms of time, staff, and resources will rise as weed control efforts intensify. We also found mowing, hand weeding, and herbicide treatments risk damage to desirable plantings. Damage often occurs as plants are trampled, accidentally cut, or killed from herbicide over-spray.

We calculated mean and median invasive species cover values for 28 of 29 sites included in this study ($\bar{X}$ = 26%; median = 25%; s = 19%) (Figure 6). These estimates were used to address success standards, contingency plans, and to inform management activities intended to improve site conditions during the final year of the intended monitoring period. These data suggest an invasive species cover threshold of 20 to 25 percent may be more reasonable and achievable in most cases.

We found high levels of invasive species cover did not necessarily prevent mitigation projects from meeting other site goals, objectives, and success standards. One site investigated for this study had 72% ($CI_{90\%}$ = 61-83%) invasive species cover in the wetland. In spite of the high cover of invasive species, this site met or exceeded four of six standards for tree and shrub cover in three different wetland zones with cover values ranging from 58% ($CI_{90\%}$ = 49-67%) to 94% ($CI_{99\%}$ = 85-100%). This site provides many of its intended wildlife and water quality improvement functions. Another site with

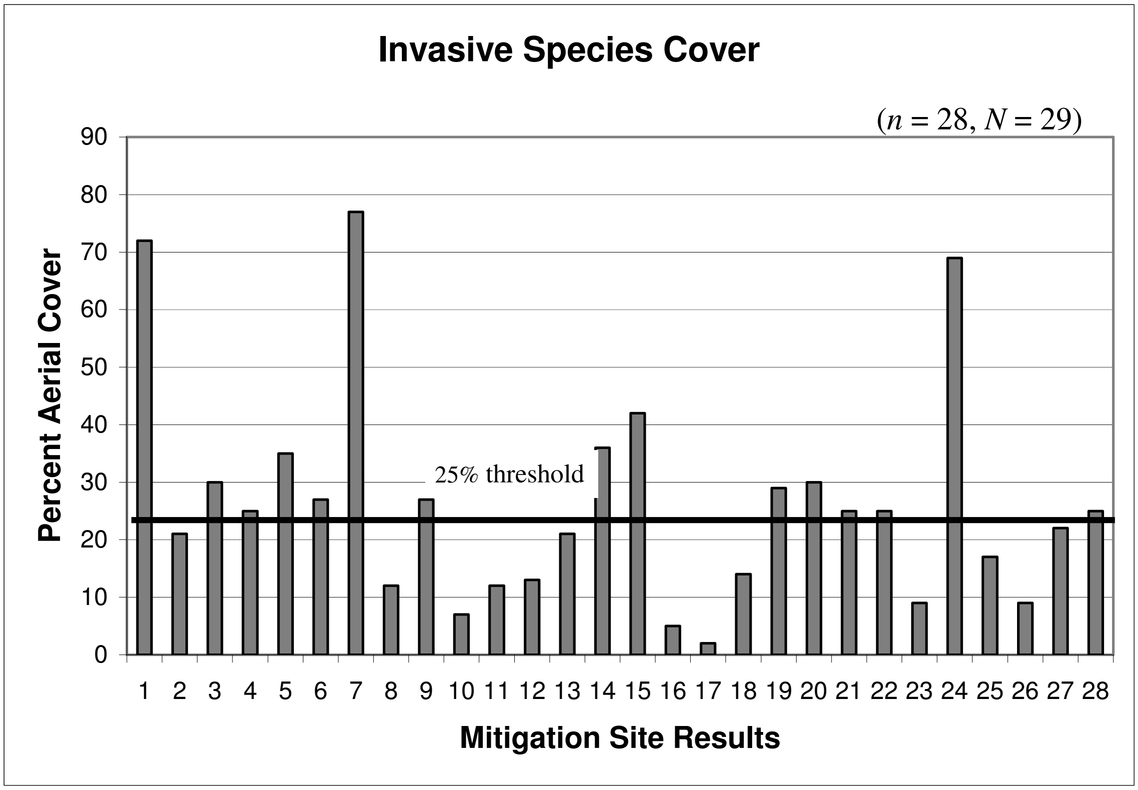

Figure 6: Invasive species cover estimates were completed for 28 of 29 mitigations sites included in this phase of the evaluation. Cover estimates were made to address site-specific success standards and contingencies as well as to inform management activities intended to improve site conditions during the final monitoring year.

just 9% ($CI_{80\%}$ = 7-11%) cover of invasive species had only 11% ($CI_{80\%}$ = 8-14%) cover of trees and shrubs in the scrub-shrub wetland zone. Though this site already provides some of its intended wildlife functions, it does not meet standards for woody species cover. However, it seems unlikely invasive species have prevented this site from attaining higher levels of shrub and tree development. In this case, other factors are responsible. Similar results were recorded for other sites we evaluated for this study. These findings suggest raising targets for invasive species cover may not inhibit site development or performance for many wetland mitigation sites. Higher invasive species thresholds may reduce negative effects from intensive weed control efforts on native, wetland woody and herbaceous plant establishment.

To assist in establishing more meaningful performance criteria, staff from the Department's Wetland Assessment and Monitoring Program are now included in the internal review of draft site mitigation plans. With this review, success standards that are immeasurable or unachievable are identified before the site permitting process is complete. In addition, site goals and objectives are checked for their clarity and completeness. These efforts complement and support ongoing work at WSDOT and the regulatory agencies to establish functions-based performance measures that will provide a better gauge of mitigation site performance in the future.

Several studies suggest (Kentula et al. 1992; Johnson et al. 2000; NRC 2001) active management improves mitigation site success. In 2001, WSDOT implemented an adaptive management strategy to help guide mitigation site management activities. These activities include routine weed control, vegetation replanting, and amendments to the soil. In some cases, failure to meet the goals, objectives, or success standards of a mitigation plan requires more resource intensive remedial action. These actions may include installation of temporary irrigation systems, site redesign, or regrading. Consistent with findings from other studies (Ringold et al. 1996; Thom and Wellman 1996; Elzinga et al. 2001), the Department recognizes valid monitoring data is central to the success of these efforts. This monitoring information is used to make management decisions that improve the condition of wetland mitigation sites and help to ensure compliance with regulatory permits. Recently, a stable and innovative funding source has been established for management of WSDOT mitigation sites. Wetland site restoration crews are improving response time and site management procedures.

<u>Wetland Ratings</u>

Looking at just replacement wetland acreage, the 27 mitigation sites included in this phase of this evaluation have produced a net gain in Category II wetlands (14.43 acres) and a net loss in Category III and Category IV wetlands (19.11 acres).[6] These findings indicate that, in general, WSDOT mitigation efforts have been effective in minimizing impacts to higher quality wetlands. In most cases, we found the Department successfully replaced lower quality wetlands with wetlands of equal or higher value. However, impacts to Category I wetlands (0.73 acre) were recorded for three mitigation sites from this sample. Although one of these projects successfully restored 0.35 acre of Category I wetland, small size and location prevented the two other projects from achieving the same result. A net loss of Category I wetland (0.38 acre) was recorded.

These results suggest that wetland functions may have been improved on many of the Department's mitigation sites. To support this assertion, a qualitative wetland functions assessment was performed for each of the mitigation sites included in this study using the *Wetland Functions Characterization Tool for Linear Projects* (Null et al. 2000). Results from these assessments indicate general habitat suitability and amphibian habitat are provided by 25 of 30 mitigation sites included in this study. Organic matter production and export, aquatic invertebrate habitat, flood flow alteration, and sediment removal functions are provided by 20 to 26 of the mitigation sites we studied. On average, based on findings from this study, seven of the 14 functions we assessed are likely to be provided by most WSDOT mitigation sites at some level. Wetland function data are summarized in Table 2.

Planning on a regional or watershed scale helps to maximize the functions and values of created and restored wetland mitigation sites (Allen and Feddema 1996; Bedford 1996; NRC 2001). In previous analyses, we identified site location within appropriate hydrogeologic and climatic settings as one of the most important factors in determining

[6] Incomplete data records eliminated three of the oldest sites from this phase of the evaluation.

Functions (*from* Null et al. 2000)	**Sites that Minimally Provide Listed Function**	**Sites that Likely Provide Listed Function**
Flood flow alteration	5	16
Sediment removal	5	15
Nutrient and toxicant removal	2	17
Erosion and shoreline stabilization	2	9
Organic matter production and export	9	17
General habitat suitability	2	23
Habitat for aquatic invertebrates	0	23
Amphibian habitat	6	19
Wetland-associated mammals	7	11
Wetland-associated birds	1	15
General fish habitat	1	1
Native plant richness	7	12
Educational or scientific value	0	0
Uniqueness or heritage	0	1

Table 2: This table summarizes functions provided by WSDOT wetland mitigation sites included in this study. Columns two and three indicate the total number of sites that "minimally" or "likely" provide the listed functions. Organic matter production and export, general habitat suitability, and amphibian habitat are the most frequently provided functions from this sample of mitigation sites.

site success. Nine of the 30 mitigation sites we evaluated for this study were constructed within the highway right-of-way in highly developed, urban settings. All of these sites were intended to replace lost wildlife habitat functions. We believe the Department could increase habitat functions and values for many of its wetland mitigation sites by looking beyond the immediate project area. Other studies affirm these conclusions. Magee et al. (1999) found mitigation sites located in the Portland, Oregon metropolitan area frequently showed signs of diminished structure and function, while Gallihugh and Rogner (1998) and Morgan and Roberts (1999) conclude sites surrounded by low levels of human development are generally more successful.

CONCLUSIONS

Results from this study indicate that, overall, WSDOT's wetland mitigation efforts are effective at minimizing impacts to higher value wetlands and replacing the required wetland area. However, results from this study also demonstrate that WSDOT's wetland mitigation sites are not completely effective. Only one of the 30 mitigation sites reviewed for this study met all of the specified goals, and a few had significant shortfalls. Sixteen of 30 mitigation sites did not obtain their required wetland acreage, and only 96 of 173 performance standards were achieved during the intended monitoring period for sites included in this study. Poor site selection, improper site design, inadequate maintenance practices, and permit requirements that cannot be reasonably achieved within the specified timeframe are common reasons for not meeting these performance measures.

Some problems observed on older mitigation sites have already been addressed through improvements in the Department's mitigation process. WSDOT is currently planning and implementing remediation activities at the sites that have not met their regulatory obligations and will continue site monitoring until these obligations have been fulfilled. The Department is also using the results from this study to improve future wetland mitigation site design, construction, and management.

RECOMMENDATIONS

For most of the study sites, it is difficult to identify the exact cause for some of the problems that were observed in achieving desired acreage and site performance standards. However, given what we have learned from this study and from our collective experience monitoring more than 100 mitigation sites across the state, we believe there are actions that could be taken that would improve permit compliance and environmental success at WSDOT mitigation sites. Therefore, we make the following recommendations:

- WSDOT environmental and landscape design staff should develop a comprehensive set of wetland mitigation design standards similar to the WSDOT Highway Runoff Manual (WSDOT 2004). These design standards should address all aspects of wetland mitigation including wetland impact assessment, site selection, design, construction, monitoring, and site management.

- Clearly define the roles and responsibilities of WSDOT staff (and/or consultants) involved in wetland mitigation to assure that persons with the necessary technical expertise are given the authority to make decisions regarding site selection, design, permit negotiation, construction, monitoring, and site management.

- Continue discussions with regulatory agencies to mutually establish functions-based performance measures that satisfy the goals of wetland mitigation and that can be realistically achieved within the specified monitoring duration.

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